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PART II
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A STUDY OF PARACHUTE SEAM DESIGN CRITERIA

Part II — Investigation of the Strength of Nylon Webbing Joints

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WRIGHT AIR DEVELOPMENT CENTER

FOREWORD

This report, phase II of a study of seam characteristics, was prepared by Pioneer Parachute Company, Inc., of Manchester, Connecticut, under Air Force Contract No. AF 33(616)-2807. This contract was initiated under Project Number 6065, "Parachute Performance and Design Studies," and Task Number 61512, "Parachute Stresses and Airflows," and administered under the direction of the Equipment Laboratory, Directorate of Development, Wright Air Development Center, with Mr. Alfons Hegele as project engineer.

ABSTRACT

The purpose of Phase II of this investigation was to determine the most efficient joint obtainable, using presently known fabrication techniques to join the cords and webbings specified in the contract.

The investigation attempts to evaluate the most efficient joint with respect to fabrication techniques, as well as strength considerations.

The variables considered were:

1. Type of joint
2. Size of thread and sewing needle
3. Pattern of stitching
4. Number of stitches per inch

The data shows that the most efficient joint in Nylon Cords of the MIL-C-5040 type is one in which the end of one cord is superimposed on the other and stitched with a two-step zig-zag stitch pattern. Thread size and length of stitching is a function of the cord strength.

The most efficient joint in Nylon Cords of the MIL-C-7515 type (coreless) is one in which one of the free ends of the cords to be joined is threaded into the other for a certain distance and then stitched with a two-step zig-zag stitch. The thread size, length of stitching and distance which one end is threaded into the other is a function of the strength and diameter of the cord.

The most efficient joint in the nylon webbings that were tested is one in which the stitching pattern is of two, three, four or six point configuration. The number of points in the stitching pattern is a function of the width of the webbing. The size of the thread and the length of the stitching pattern are functions of the strength of the webbing.

Further tests were conducted with the most efficient webbing joints, to determine if the efficiency could be increased by the addition of reinforcing webbings and tapes. Test results show a definite increase in efficiency in the reinforced joints.

As a result of the tests, it can be stated that the most efficient non-reinforced webbing joint is of the two, three, four or six point configuration, with the number of points depending upon the width of the webbing. The overall efficiency of this type of joint can be raised substantially by the addition of reinforcing webbings, but this makes fabrication more difficult and is more costly.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

R. A. Sutton Squadron Leader. R.A.F./U.S.A.F

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Colonel, USAF
Chief, Equipment Laboratory

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I. INTRODUCTION

Phase II covers the investigation of the fabrication methods and the strength of joints made with nylon cords and webbings, presently used for suspension lines and risers of parachutes. The investigation attempts to determine the highest joint efficiency obtainable, with lowest amount of stitching, compatible with the presently known fabrication techniques.

In some cases, the most efficient joint is not the most desired joint from the standpoint of efficient and economical production. Where such conflict arises, the joints are evaluated in relation to their ease of manufacture as well as their strength efficiency.

The manufacturing equipment, necessary for the fabrication of the required test samples, was selected from regular production machinery and set aside for use on this program.

The equipment included the following machinery:

1. Single needle sewing machine (111 W 151) capable of stitching with Size "E", "F", "FF" and 3 cord thread.

2. Single needle sewing machine (97-10) capable of stitching with 5, 6 and 8 cord thread.

3. Zig-zag stitch sewing machine (17 W 15) capable of stitching with Size "E", "F", "FF" and 3 cord thread.

4. Miscellaneous equipment, such as, hot wire cutters, rotary blade cutters, waxing equipment and small tools.

The testing equipment, necessary to the completion of the program, included the following:

Pioneer Parachute Co., Inc.

1. Tinius Olsen testing machine capable of testing webbings up to 20,000 lbs. tensile strength.

2. Scott Tester - Model J-2 capable of testing tapes, webbings and cords up to 500 lbs. tensile strength.

3. Scott Tester - Model X-5 capable of testing threads up to 20 lbs. tensile strength.

Cheney Brothers Laboratories

1. Scott Tester - Model Q capable of testing tapes, webbings and cords up to 2000 lbs. tensile strength.

Massachusetts Institute of Technology

1. Baldwin Southwark Testing Machine capable of testing materials up to 300,000 lbs. tensile strength.

In addition to the strength testing machinery, various other laboratory equipment is available at Cheney Brothers Textile Laboratory. A partial list would include conditioning ovens, twist testers, abrasion tester and various small tools.

The general test procedure conforms to Specification CCC-T-191b, as outlined in the contract. Wherever possible the tests were performed under standard conditions. An exception proved necessary in the testing of the 20,000 lbs. and 40,000 lbs. webbings. It was necessary to test these webbings at the Physical Testing Laboratories of the Massachusetts Institute of Technology. These laboratories are not conditioned, hence, the webbings were necessarily tested under prevailing conditions at the laboratory.

The variables encountered in the manufacture of the test specimens were:

1. Varying stitches per inch.

2. Varying thread tension.

3. Inability of operator to maintain precise stitch patterns on the heavier webbings.

4. Tight and loose stitching, due to the webbings becoming hard and inflexible during stitching.

The variables encountered in testing were:

1. Variation in strength, between test samples of the same lots, due to inherent variance in webbing strength.

2. Strength difference due to a variation in stitches per inch between samples.

II. SPECIMEN FABRICATION

1. Nylon Cord, MIL-C-5040, Type II and III

The first joint specimens to be fabricated and tested were nylon cords, MIL-C-5040, Type II and III. These tests are tabulated under Series I, Page 21.

Prior experience with this type of cord (core yarns encased in a braided sleeve) had shown that the highest basic efficiency was obtained by superimposing the cord ends, one on the other, and stitching with a two step zig-zag. Further tests were conducted to determine the optimum length of overlap, stitches per inch and thread size.

Figure 1, Page 5, shows the comparison of the side by side vs. superimposed construction. All stitching was done with Nylon Thread, MIL-T-7807, Type I, Class I, Size "E", 8-11 stitches per inch counting on side row. Stitching was 1/8 $\pm$ 1/32 wide.

The "side by side" construction ("A") yielded an average strength of 302 lbs. and the stitching failed in all cases.

The "superimposed" construction ("B") yielded an average strength of 328 lbs. and the cord failed in all cases.

2. Nylon Cord, Coreless, MIL-C-7515, Type II and VI

This cord is of "coreless" braided construction. The superimposition method of joining, as outlined for the MIL-C-5040 type cords, proved less efficient for the "coreless" cord.

Prior experience had proved that the highest basic efficiency obtained with this type of cord was obtained by threading the cord into itself and then stitching with a two step zig-zag stitch for an optimum distance. The tests of the "coreless" type cords are tabulated under Series II, Pages 22 & 23.

3. Nylon Webbing, MIL-W-5625, 1000 Lbs. and 3000 Lbs. t.s.

The MIL-W-5625 webbings were used to test the many joint stitch patterns, thread sizes and stitches per inch to determine the most efficient joint to be used on other webbings. The various configurations and their respective series numbers are discussed in detail, in another section of the report.

4. Nylon Webbing, MIL-W-4088, Type X

The MIL-W-4088, Type X webbing specimens were constructed in the various joints which exhibited superior qualities in the tests of the MIL-W-5625 webbings.

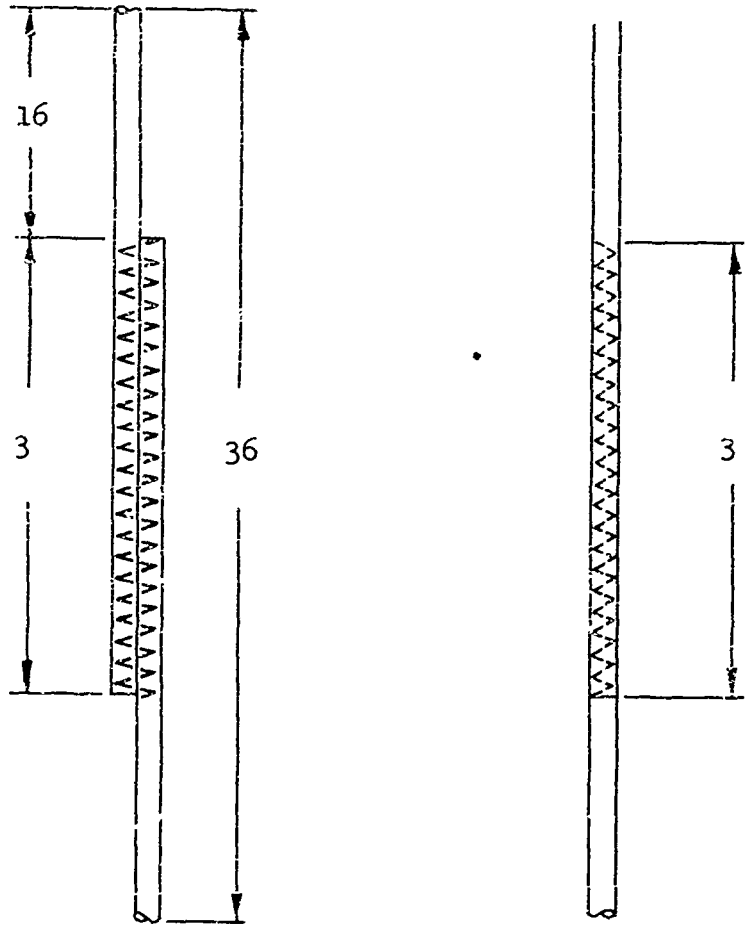
It was on the MIL-W-4088, Type X webbing that the first of the reinforced end joints were tested. (See Series XI and XII, Pages 33 & 34.)

5. Nylon Webbing, MIL-W-4088, Type XVIII

The various joints of superior qualities were duplicated in the MIL-W-4088, Type XVIII webbing. The three specimens of the longitudinally reinforced joints were constructed with the Type XVIII webbing.

6. Nylon Webbing, MIL-W-5787, Type I and II

The MIL-W-5787, Type I and II (20,000 lbs. and 40,000 lbs.) webbing joints were fabricated in accordance with Series XXIII and XXIV, as shown on Pages 39 and 40. The reinforced type joints were not used because reinforced webbings of suitable width were not available.



Side By Side Superimposed

Comparison of Overlap Strength - Side by Side vs. Superimposed

Figure 1

III. TEST METHODS

1. Cord Tests

The nylon cords of 550 lbs. tensile strength and lower were tested on a Scott Model Q Tester of 2000 lbs. capacity. The cord specimens of the MIL-C-7515, Type VI, 2000 lbs. tensile strength were tested on a Tinius Olsen testing machine.

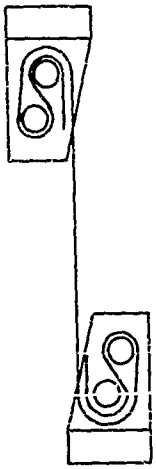
2. Webbing Tests

The webbing specimens below a rated strength of 20,000 lbs. were tested on a Tinius Olsen testing machine. The testing machine had dual ranges of 5000 lbs. and 20,000 lbs. capacity, and a jaw separation speed of 4 inches per minute.

The webbing specimens above a rated strength of 20,000 lbs. were tested at the Physical Testing Laboratory of the Massachusetts Institute of Technology at Cambridge, Massachusetts. The testing machine was a Baldwin Southwark Tester of 300,000 lbs. capacity and the jaw separation speed was 3 inches per minute.

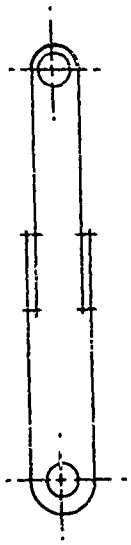
The webbings tested on the Tinius Olsen machine were held on webbing holding fixtures in the manner shown in Figure 2.

The webbings tested on the Baldwin Southwark machine were of loop form and tested over pins as shown in Figure 3.



Test Arrangement-Tinius Olsen

Figure 2



Test Arrangement-Baldwin Southwark

Figure 3

IV. ORDER OF JOINT EFFICIENCIES

The various joints are presented here with reference to the most efficient joints for individual materials. No attempt is made, at this point, to establish a universally efficient joint. In Section V, Analysis of Joint Efficiencies, the various types of joints are evaluated with respect to establishment of the most efficient joint for universal usage.

1. Nylon Cord, MIL-C-5040, Type II, 375 lbs. t.s.

The strongest joint obtained with the MIL-C-5040, Type II cord yielded an average breaking strength of 355 lbs. The low was 350 lbs. and the high was 360 lbs. The average efficiency was 77.7%, based on an average control strength of 457 lbs.

This joint was fabricated in accordance with the Series I type overlap, as shown on Page 21. The length of overlap ("L") was 6 inches and the thread was Size "F". The stitch was a two step zig-zag, 6 to 7 stitches per inch, $1/8 \begin{smallmatrix} + 1/32 \\ - 0 \end{smallmatrix}$ inches wide.

Although this proved to be the strongest joint, it is not the most efficient from the standpoint of the amount of stitching used. The next strongest joint, using the same size thread, but only a three inch overlap in lieu of six inches, yielded an average breaking strength of 353.3 lbs. It is evident that the three inch overlap, yielding a strength of 353.3 lbs., is more efficient than the six inch overlap yielding 355 lbs., all other factors being equal.

2. Nylon Cord, MIL-C-5040, Type III, 550 lbs. t.s.

The most efficient joint obtained with the MIL-C-5040, Type III cord yielded an average breaking strength of 555 lbs., or an average efficiency of 90.2%, based on an average control strength of 615 lbs.

This joint was fabricated in accordance with the Series I type overlap, as shown on Page 21. The length of overlap ("L") was two inches and the thread was Size "FF". The stitch was a two step zig-zag, 6 to 7 stitches per inch, $1/8 \begin{smallmatrix} + 1/32 \\ - 0 \end{smallmatrix}$ inches wide.

The joint of next highest efficiency yielded an average breaking strength of 481.6 lbs., or an average efficiency of 78.4%.

This joint was fabricated in accordance with the Series I type overlap. The length of overlap was three inches and the thread was Size "F". The stitch was a two step zig-zag, 6 to 7 stitches per inch, $1/8 \begin{smallmatrix} + 1/32 \\ - 0 \end{smallmatrix}$ inches wide.

3. Nylon Cord, MIL-C-7515, Type II, 550 lbs. t.s.

The most efficient joint obtained with the MIL-C-7515, 550 lbs. t.s. cord yielded an average breaking strength of 590 lbs., or an average efficiency of 99.5%, based on an average control strength of 593 lbs.

This joint was fabricated in accordance with the Series II type overlap, as shown on Page 23. The length of overlap ("L") was 6 inches and the length of stitching was 2 inches. The stitch was a two step zig-zag with Size "F" thread, 6 to 7 stitches per inch counting on the side row, 3/16 $^{+}_{-}$ $^{1/16}_{0}$ wide.

The joint of next highest efficiency yielded an average breaking strength of 580 lbs., or an average efficiency of 97.8%.

This joint was fabricated in accordance with the Series II type overlap and was identical with the joint of highest efficiency except that Size "FF" thread was used in lieu of Size "F".

4. Nylon Cord, MIL-C-7515, Type VI, 2000 lbs. t.s.

The strongest joint obtained with the MIL-C-7515, 2000 lbs. t.s. cord yielded an average breaking strength of 2346 lbs., or an average efficiency of 97.5%, based on an average control strength of 2405 lbs.

This joint was fabricated in accordance with the Series II type overlap, as shown on Page 23. The length of the overlap was 6 inches and the length of the stitching was 2 inches. The stitching was a two step zig-zag with Size "FF" thread, 6 to 7 stitches per inch, 1/4 $^{+}_{-}$ $^{1/32}_{0}$ wide.

The joint exhibiting the next highest strength yielded an average breaking strength of 2340 lbs., or an average efficiency of 97.3%.

This joint was constructed the same as the joint of highest strength except that Size "F" thread was used in lieu of Size "FF".

Since the joint stitched with the lighter thread, Size "F", yielded an average strength of 2340 lbs., as against 2346 lbs. for the heavier thread, Size "FF", it is evident that the joint stitched with the lighter thread, Size "F", is the most efficient.

5. Nylon Webbing, MIL-W-5625, 1000 lbs. t.s.

The most efficient joint obtained with the MIL-W-5625, 1000 lbs. t.s. webbing yielded an average breaking strength of 1490 lbs., or an average efficiency of 100.9%, based on an average control strength of 1476 lbs.

This joint was fabricated in accordance with the Series XXVII, Overlap Type "A", as shown on Page 42. The length of the overlap was 6 inches and the stitch pattern was a three point cross stitch. The thread was Size "FF", 8 stitches per inch. The joint was reinforced between the webbings by Nylon Webbing, MIL-W-4088, Type I, 500 lbs. t.s.

The joint of next highest efficiency yielded an average breaking strength of 1488 lbs., or an average efficiency of 100.8%.

This joint was constructed in accordance with Series XXVII, Overlap Type "B", as shown on Page 42. The length of overlap was 6 inches and the stitch pattern was a three point cross stitch. The thread was Size "FF", 8 stitches per inch. The joint was reinforced on both sides by Nylon Webbing, MIL-W-4088, Type I, 500 lbs. t.s.

6. Nylon Webbing, MIL-W-5625, 3000 lbs. t.s.

The most efficient joint obtained with the MIL-W-5625, 3000 lbs. t.s. webbing yielded an average breaking strength of 3833 lbs., or an average efficiency of 94.9%, based on an average control strength of 4040 lbs.

This joint was fabricated in accordance with the Series IV, Overlap Type "C", as shown on Page 27. The length of the overlap was 6 inches and the stitch pattern was a three point cross stitch. The thread was Size 3 cord, 11 stitches per inch.

The joint of next highest efficiency yielded an average breaking strength of 3746 lbs., or an average efficiency of 93%.

This joint was fabricated in accordance with the Series IV, Overlap Type "C", as shown on Page 27. The length of the overlap was 6 inches and the stitch pattern was a three point cross stitch. The thread was Size 3 cord, 8 stitches per inch.

The joint of next highest efficiency yielded an average breaking strength of 3693 lbs., or an average efficiency of 91.4%.

This joint was fabricated in accordance with the Series XXII, Overlap Type "A", as shown on Page 38. The length of overlap was 6 inches and the stitch pattern was a four point cross stitch. The overlap was reinforced between the webbings by 1000 lb. Nylon Tape, MIL-T-5038, Type IV. The thread was Size 3 cord, 8 stitches per inch.

7. Nylon Webbing, MIL-W-4088, Type X, 8700 lbs. t.s.

The most efficient joint obtained with the MIL-W-4088, 8700 lb. nylon webbing, yielded an average breaking strength of 9100 lbs., or an average efficiency of 92.9%, based on an average control strength of 9800 lbs.

This joint was fabricated in accordance with Series XXVI, Overlap Type "B", as shown on Page 41. The thread size was 6 cord, 6 stitches per inch, and the length of overlap was 8 inches. The stitch pattern was a 4 point cross stitch and the overlap was reinforced on both sides by Nylon Webbing, MIL-W-4088, Type XII, 1200 lbs. t.s.

The joint of next highest efficiency yielded an average breaking strength of 8620 lbs., or an average efficiency of 88.0%.

This joint was fabricated in accordance with Series XXVI, Overlap Type "A", as shown on Page 41. The thread size was 6 cord, 6 stitches per inch, and the length of overlap was 8 inches. The stitch pattern was a 4 point cross stitch and the overlap was reinforced between the webbings by Nylon Webbing, MIL-W-4088, Type XII, 1200 lbs. t.s.

8. Nylon Webbing, MIL-W-4088, Type XVIII, 6000 lbs. t.s.

The most efficient joint obtained with the MIL-W-4088, 6000 lb. nylon webbing, yielded an average breaking strength of 6440 lbs., or an average efficiency of 100.1%, based on an average control strength of 6433 lbs.

This joint was fabricated in accordance with Series XVII, Overlap Type "B", as shown on Page 36. The thread size was 3 cord, 8 stitches per inch, and the length of overlap was 6 inches. The stitch pattern was a 4 point cross stitch with the overlap reinforced on both sides with 1000 lb. Nylon Tape, MIL-T-5038, Type IV.

The joint of next highest efficiency yielded an average breaking strength of 6307 lbs., or an average efficiency of 98.1%.

This joint was fabricated in accordance with Series XVIII, Overlap Type "C", as shown on Page 36. The thread size was 3 cord, 8 stitches per inch, and the length of overlap was 8 inches. The stitch pattern was a triple row of zig-zag stitching, 1/4 inch wide.

The joint of next highest efficiency yielded an average breaking strength of 6200 lbs., or an average efficiency of 96.4%.

This joint was fabricated in accordance with Series XVII, Overlap Type "B", as shown on Page 36. The thread size was 3 cord, 8 stitches per inch, and the length of overlap was 8 inches. The stitch pattern was a four point cross stitch with the overlap reinforced on both sides with 1000 lb. Nylon Tape, MIL-T-5038, Type IV.

9. Nylon Webbing, MIL-W-5787, Type I, 20,000 lbs. t.s.

The most efficient joint obtained with the MIL-W-5787, 20,000 lbs. webbing. yielded an average breaking strength of 21,000 lbs.

This joint was fabricated in accordance with Series XXIV, as shown on Page 39. The thread size was 8 cord, 6 stitches per inch, and the length of overlap was 10 inches. The pattern was a six point cross stitch reinforced at both ends by Nylon Webbing, MIL-W-4088, Type XII.

10. Nylon Webbing, MIL-W-5787, Type II, 40,000 lbs. t.s.

The most efficient joint obtained with the MIL-W-5787, 40,000 lbs. webbing, yielded an average breaking strength of 35,500 lbs.

This joint was fabricated in accordance with Series XXIII, Reinforced End Overlap, as shown on Page 39. The thread size was 8 cord, 6 stitches per inch, and the length of overlap was 14 inches. The pattern was a six point cross stitch.

11. Nylon Webbing, MIL-W-4088, Type XIII, 6000 lbs. t.s.

The MIL-W-4088, 6000 lb. webbing was introduced into the test program to determine if the results obtained in the tests of the MIL-W-4088, Type X webbing joints would hold true for the Type XIII, which is of a similar weave. The results indicate that the most efficient joints obtained in the Type X weobing joints were, in general, the most efficient joints in the Type XIII webbing tests. The most efficient joint obtained with the MIL-W-4088, Type XIII, 6000 lb. webbing, yielded an average breaking strength of 6353 lbs., or an average efficiency of 86.9%, based on an average control strength of 7313 lbs. This joint was fabricated in accordance with Series XII, Page 34.

V. ANALYSIS OF JOINT EFFICIENCIES

1. Nylon Cords, MIL-C-5040, Types II and III.

The MIL-C-5040 type cords, core yarns encased in a braided sleeve, derive the major portion of their strength from the core yarns. An increase in tensile strength, in such cords, is realized by the addition of core yarns. The function of the sleeve is not primarily one of strength, but rather, to hold the core yarns in place.

Hence, it would appear that the most efficient joint in this type of cord would be one in which the stitching pattern encompassed and bound together the maximum number of core yarns in the overlap ends, one to the other.

To illustrate this point, a typical sectional view of the cord is shown in Figure 4 along with two methods of stitching the overlapped ends. It is evident from Figure 4 that the most efficient type of overlap would be one constructed with a two step zig-zag stitch, in which the ends of the cords were superimposed, one on the other.

After the general construction of the joint was determined, the optimum length of overlap, thread size and stitches per inch was established by test.

For the Nylon Cord, MIL-C-5040, Type II, the test data indicates that the most efficient joint, on the basis of length of overlap, thread size and stitches per inch, was the joint yielding an average breaking strength of 353.3 lbs. (77.3% efficient) for three inches of overlap, stitched with Size "F" thread as shown in Series I, Page 21.

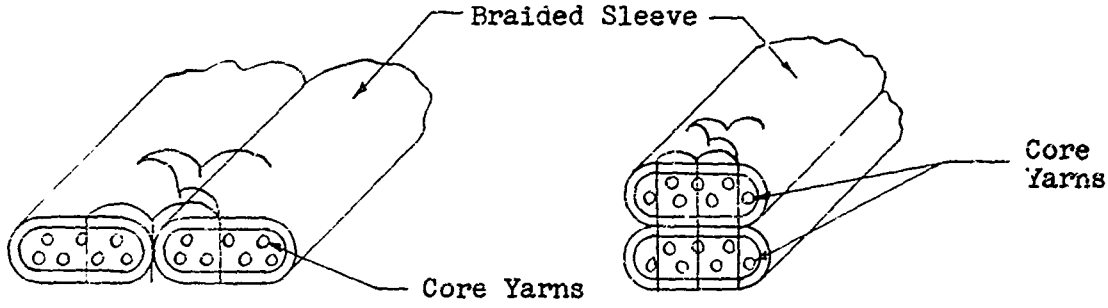
For the MIL-C-5040, Type III, cord, the most efficient joint was the one yielding an average breaking strength of 555 lbs. The length of overlap was two inches and the thread was Size "FF". (See Series I, Page 21.)

2. Nylon Cords, MIL-C-7515, Types II and VI.

As explained in Section II, Specimen Fabrication, the plain overlapping of the "coreless" cord proved less efficient than the method of threading one end of the cord into the other and then stitching for an optimum length.

The joint formed by superimposing one end of the Type II cord on the other and zig-zag stitching, yielded an average breaking strength of 555 lbs. for a two inch overlap in which the cord failed. The joint formed by threading the cord ends, one into the other for 6 inches and then zig-zag stitching for two inches, yielded an average breaking strength of 590 lbs.

The test data on the "coreless" type cords show the most efficient joint construction to be one, in which, an end of the cord to be joined is threaded into another and then stitched with a two step zig-zag stitch for an optimum length. The length of stitching, the size of thread, and the length of insertion of one cord into the other, would be a function of the strength of the specific cord.



Side by Side Superimposed

Cord Joint Comparison

Figure 4

3. Nylon Webbing, MIL-W-5625, 1/2 Inch Wide, 1000 lbs. t.s.

The results of the joint tests on the MIL-W-5625, 1000 lbs. t.s, webbing, showed the most efficient construction to be the reinforced type joint, stitched with a 3 point cross stitch pattern. This joint utilizes a reinforcing webbing inserted between the overlapped ends of the 1000 lb. webbing and extending for a distance of 1 inch beyond the ends of the overlap. (See Series XXVII on the Overlap Type "A", Page 42.)

The next most efficient construction, as indicated by the test results, utilizes reinforcing webbings on either side of the overlap and extending beyond the exposed ends, for a distance of 1 inch. This joint also uses a 3 point cross stitch pattern. On both joints the thread used was Size "FF", 8 stitches per inch.

The average breaking strengths realized were, 1490 lbs. for the most efficient joint and 1488 lbs. for the joint of next highest efficiency. The negligible difference in strength realized would make both joints equally efficient, on the basis of strength alone. A more complete analysis of these types of overlaps, will be made when considering the most efficient joint for universal application.

4. Nylon Webbing, MIL-W-5625, 1 Inch Wide, 3000 lbs. t.s.

The test data obtained from the webbing joint tests on the MIL-W-5625, 3000 lbs. webbing, shows the most efficient joint to be a plain overlap joint stitched with 3 cord thread, 11 stitches per inch, in a 3 point cross stitch pattern. The length of overlap was 6 inches.

The joint of next highest efficiency was precisely the same construction, with the exception that 8 stitches per inch were used in lieu of 11 stitches per inch.

The joint of next highest efficiency was the reinforced type joint, utilizing a reinforcing webbing between the overlapped ends of the 3000 lb. webbing. A comparison of the various overlaps, here mentioned, will be found in Section VI, Analysis of Webb Joints for Universal Usage.

5. Nylon Webbing, MIL-W-4088, Type X, 8700 lbs. t.s.

The reinforced type joint, utilizing a reinforcing webbing on both sides of the overlap, proved to be the most efficient joint tested with the MIL-W-4088, 8700 lb. webbing.

The reinforced joint, utilizing the reinforcing webbing between the overlap webbs, proved to be the next highest in efficiency.

The most efficient joint yielded an average breaking strength of 9100 lbs., whereas, the joint of next highest efficiency in strength realized is sufficient to favor the doubly reinforced overlap (Series XXVI, Overlap Type "B", Page 41) over the joint with the single reinforcing webbing between the overlap. (See Series XXVI, Overlap Type "A", as shown on Page 41.

6. Nylon Webbing, MIL-W-4088, Type XVIII, 6000 lbs. t.s.

The reinforced type joint again proved to be the most efficient in the case of the MIL-W-4088, Type XVIII, 6000 lb. webbing. This joint was the Series XVII, Overlap Type "B", as shown on Page 36, and utilized reinforcing webbings on both sides of the overlapped webbs.

7. Nylon Webbing, MIL-W-5787, Type I, 20,000 lbs. t.s.

The joints fabricated and tested with this webbing did not include longitudinal reinforced joints. No webbing of sufficient width was immediately available for use in these tests. As a result, the webbings were tested with the wrapped end type of reinforcement as described in Series XXIV, Page 39. These were also made with the plain type overlap, utilizing 4 point and 6 point cross stitch patterns.

8. Nylon Webbing, MIL-W-5787, Type I, 20,000 lbs. t.s.

These joints were fabricated in accordance with the configuration shown in Table XX.

VI. ANALYSIS OF JOINTS FOR GENERAL USAGE

1. Basis of Evaluation

Many different types of joint constructions were fabricated and tested. Some of the initial configurations were eliminated quite readily because of obviously inferior qualities, which would be present for any type of webbing or cord used. The others were not so easily analyzed. It was necessary, in some cases, to rate a joint of lower strength above one of higher strength on the basis of some factor, such as, a lesser amount of stitching used, a shorter overlap or a smaller size thread.

Other criteria for evaluation were facility of fabrication, necessity for additional meterials (reinforcing webbings and necessity for non-standard materials or machinery.

2. Breaking Strength vs. Stitches per Inch

In general, it was found that the breaking strength of a particular joint was at its lowest, for a given length of overlap, if 5 stitches per inch were used. This was not due entirely to stitch failure. Webbing failures occurred in a substantial number of cases where the 5 stitches per inch pattern was used. A definite increase in strength invariably resulted as the stitches per inch were increased to 8. It was found that in the majority of cases, as the stitches per inch were increased to 11, the strength of the joint was reduced. The data presented in Table I, Page 16, illustrates the variations in breaking strength due to variation in stitches per inch.

3. Comparison of Stitch Patterns

The following types of stitch patterns were tested:

1. Six Point Cross Stitch
2. Four Point Cross Stitch
3. Three Point Cross Stitch
4. Split Four Point Cross Stitch
5. Box Stitch
6. Zig-Zag Stitch - Single, double and triple row
7. Diamond Stitch

The highest joint efficiencies for the webbings were realized in overlaps using the three, four and six point cross stitch patterns. Where reinforcing webbs were used in conjunction with the three, four and six point cross stitch patterns, increases in efficiency as high as 10% were realized.

TABLE I

COMPARISON OF BREAKING STRENGTH AND STITCHES PER INCH

NYLON WEBBING	SIZE THREAD	ST./IN.	STITCH PATTERN	BREAKING STRENGTH (AVERAGE)	OVER-LAP "L"	COMMENT
MIL-W-5625, 1/2" w., 1000 lbs.	"F"	5	3 point cross stitch	1375	6	Stitching failed on one specimen, webbing failed on rest.
MIL-W-5625, 1/2" w., 1000 lbs.	"F"	8	3 point cross stitch	1432	6	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2" w., 1000 lbs.	"F"	11	3 point cross stitch	1328	6	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	5	3 point cross stitch	1418	6	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	3 point cross stitch	1470	6	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	11	3 point cross stitch	1297	6	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	5	4 point cross stitch	3220	4	Webbing failed on one specimen, stitching failed on rest.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	4 point cross stitch	3512	4	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	11	4 point cross stitch	3313	4	Webbing failed at end of stitching on all specimens.

The advisability of using a three, four or more point cross stitch, appears to be governed by the width of the webbing in question. The results indicate that the use of four point stitching on the narrow webbing, causes crowding of the stitching and results in a strength reduction. This reduction in strength has two apparent causes; first, a crowding of the stitches into a smaller area, thus, excessively restricting the elongation of the fibers within the stitch pattern and secondly, bringing the points of termination of the stitching closer together in the lateral plane. This results in more fibers being stressed at a given lateral line than if the termination points were more widely spaced. Hence, for a narrow webbing, one would use a three point cross stitch rather than a four point cross stitch. This can readily be seen by comparison of the results of the Series XXV and Series XXVII tests on Pages 41 and 42.

4. Burned Ends vs. Plain Ends

Tests were made to determine the effect of overlapped webbing ends which were cut with a hot wire on the strength of the joint. Comparative tests were made of joints in which the overlapped webbing ends were cut with a rotary blade cutter, but were not burned or seared. Nylon Webbing, MIL-W-4088, Type X, 8700 lbs. t.s., was used to make the comparative tests. The joint construction was a 4 point cross stitch pattern, using 6 cord thread, 6 stitches per inch and an 8 inch overlap. The stitching was carried beyond the ends of the overlapped webbings for a distance of approximately 1/8 inch. The average breaking strength of the burned end joints was 8020 lbs. The average breaking strength of the plain end joints was 8120 lbs. The low breaking strength on the burned end joints was 7900 lbs. The low breaking strength on the plain end joints was 7940 lbs.

The results indicate that there is not an appreciable reduction in strength, due to the stitching passing over the burned ends of the overlapped webbings. However, it must be noted that the burning (searing) of the test webbings was controlled, whereas, webbings burned in production might not receive as careful attention. This might result in excessive burning and resulting sharp edges at the webbing ends to cause excessive thread breakage and resultant propagation of thread failure throughout the stitch pattern. It is therefore recommended that, wherever possible, searing of the webbing ends be eliminated or the stitching be stopped short of the webbing ends.

If the stitching is stopped short of the webbing ends, this will result in a reduction of the stitch length amounting to approximately 3/8 to 3/4 of an inch. This data indicates that a strength reduction of 200 to 300 lbs. may result on a webbing of 1400 lbs. control strength.

5. Effect of Thread Size

In general, the use of a larger size thread will result in an increase in strength if all other factors are equal. Table IA illustrates this trend for the smaller size thread, Size "E" to Size "FF".

It is usually possible to reduce the amount of stitching necessary to obtain a given breaking strength when a larger size thread is used.

VII. CONCLUSIONS

1. Nylon Cord, MIL-C-5040

The most efficient joint construction for general use on the Nylon Cord, MIL-C-5040, and other cords of generally similar construction, is the superimposed overlap, stitched with a two step zig-zag stitch. The length and width of the stitch would be a function of the strength and diameter of the cord in question.

2. Nylon Cord, MIL-C-7515

The most efficient joint construction for general use on the Nylon Cord, MIL-C-7515, and generally similar cords, is the type in which one of the joint ends is threaded into the other and then stitched with a two step zig-zag stitch for an optimum length. The length for which one end is threaded into the other, and the optimum length and width of zig-zag stitching, would be a function of the strength and diameter of the cord in question.

3. Nylon Webbing

On the basis of the test data obtained, the most efficient joint construction for general use on the webbings tested and those of generally similar construction, would be one using a three, four or six point cross stitch pattern, depending upon the width and strength of the webbing used. The reinforced type joints exhibit the highest efficiencies, except for the MIL-W-5625, 3000 lbs. webbing, but require additional materials, (reinforcing webbings) to attain the higher breaking strengths.

For a plain webbing joint, with no reinforcing webbings, the most efficient construction is that using a three or more point stitch pattern, based on the width and strength of the webbing. The length of stitching and thread size would also be a function of the strength of the webbing.

For reinforced joints, the most efficient joint would be that using the plain joint construction, but having a reinforcing webbing of suitable width and strength, between the overlapped webbings.

TABLE IA

THREAD SIZE VS. BREAKING STRENGTH

MATERIAL	TH'D. SIZE	ST. IN. "L"	BREAKING STRENGTH	COMMENT
Nylon Cord, MIL-C-5040, 375 lbs.	"E"	6-7 3	328.3	Two step zig-zag stitch. Cord failed at splice.
Nylon Cord, MIL-C-5040, 375 lbs.	"F"	6-7 3	353.3	Two step zig-zag stitch. Cord failed at splice.
Nylon Cord, MIL-C-5040, 375 lbs.	"E"	6-7 6	326.6	Two step zig-zag stitch. Cord failed at splice.
Nylon Cord, MIL-C-5040, 375 lbs.	"F"	6-7 6	355	Two step zig-zag stitch. Cord failed at splice.
Nylon Cord, MIL-C-7515, 550 lbs.	"E"	6-7 3	565	Two step zig-zag stitch. Cord failed at splice
Nylon Cord, MIL-C-7515, 550 lbs.	"F"	6-7 3	571.6	Two step zig-zag stitch. Cord failed at splice.
Nylon Cord, MIL-C-7515, 550 lbs.	"E"	6-7 6	566.6	Two step zig-zag stitch. Cord failed at splice.
Nylon Cord, MIL-C-7515, 550 lbs.	"F"	6-7 6	573.3	Two step zig-zag stitch. Cord failed at splice.
MIL-W-5625, 1/2" w., 1000 lbs.	"F"	5 6	1,378	Three point cross stitch. Webbing failed at end of stitching.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	5 6	1,418	Three point cross stitch. Webbing failed at end of stitching.
MIL-W-5625, 1/2" w., 1000 lbs.	"F"	11 6	1,328	Three point cross stitch. Webbing failed at end of stitching.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	11 6	1,297	Three point cross stitch. Webbing failed at end of stitching.
MIL-W-5625, 1/2" w., 1000 lbs.	"F"	8 6	1,432	Three point cross stitch. Webbing failed at end of stitching.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8 6	1,470	Three point cross stitch. Webbing failed at end of stitching.

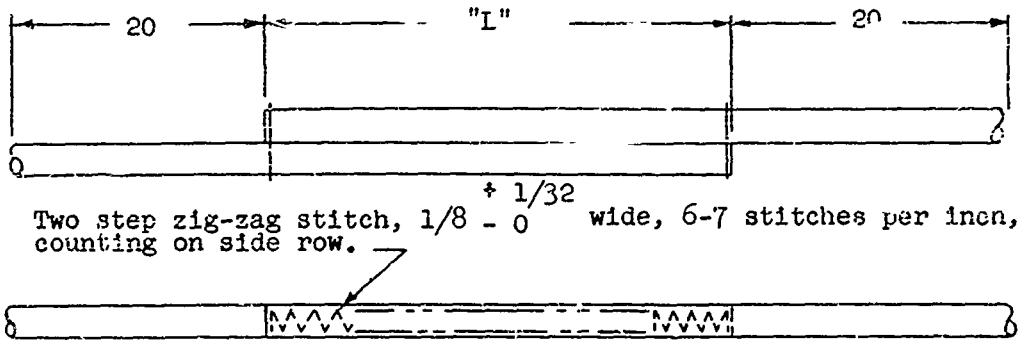
The reinforced joints, using a longitudinally reinforced webbing, are of two types. One type uses the reinforcing webbing between the overlapped webbings and extends for a certain distance beyond the ends of the overlap. The other type of longitudinally reinforced joint uses two reinforcing webbings, one on each side of the overlap and extending beyond the exposed ends for a certain distance.

In general, these two types of reinforced joints are of substantially the same efficiency. One exception would be the MIL-W-4088, Type X, 8700 lbs. webbing, where the strength of the doubly reinforced joint exceeded the strength of the singly reinforced joint by approximately 500 lbs.

The other type of reinforced joint (wrapped ends) are of two types. The first type uses a reinforcing webbing wrapped laterally around the exposed ends of the overlap. The second type uses a reinforcing webbing layed laterally on the top and bottom of the overlapped ends. Both of these reinforced joints are of substantially the same efficiency.

TABLE II

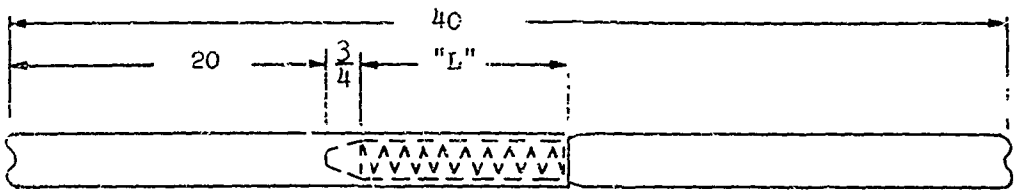
Cord Joint Test - Phase II - Series T



NYLON CORD MIL-C-5040	THREAD MIL-T-7807	"L"	BREAKING STRENGTH LBS.	EFF. %	COMMENT
Type II, 375 lbs.	Size "E"	3	328.3	71.8	Cord failed at end of splice.
Type II, 375 lbs.	Size "E"	6	326.6	71.5	Cord failed at end of splice.
Type II, 375 lbs.	Size "F"	3	353.3	77.3	Cord failed at end of splice.
Type II, 375 lbs.	Size "F"	6	355	77.7	Cord failed at end of splice.
Type III, 550 lbs.	Size "E"	3	390	63.4	Cord failed at end of splice on one specimen, stitching failed on rest.
Type III, 550 lbs.	Size "E"	6	415	67.5	Cord failed at end of splice on one specimen, stitching failed on rest.
Type III, 550 lbs.	Size "F"	3	481.6	78.4	Cord failed at end of splice.
Type III, 550 lbs.	Size "F"	6	455	74.0	Cord failed at end of splice.
Type II, 375 lbs.	Size "E"	2	273	59.7	Stitching failed on all samples.
Type II, 375 lbs.	Size "F"	1	250	54.7	Stitching failed on all samples.
Type III, 550 lbs.	Size "F"	2	407	66.2	Stitching failed on all samples.
Type III, 550 lbs.	Size "FF"	2	555	90.2	Cord failed at end of splice on all samples.

TABLE III

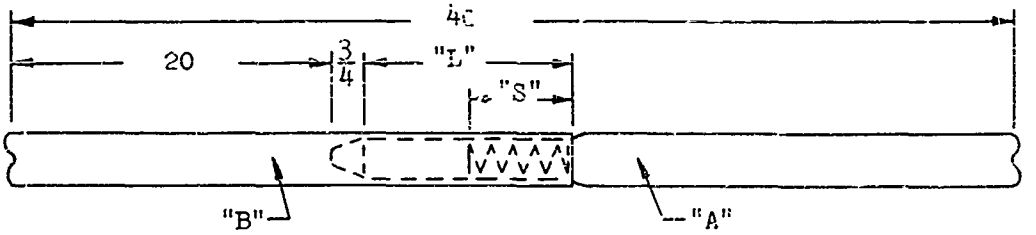
CORD JOINT TESTS - PHASE II - SERIES II



NYLON CORD MIL-C-7515	THREAD MIL-T-7807	"L"	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
Type II 550 lbs.	Size "E"	3	565	95.3	Cord failed at end of splice.
Type II 550 lbs.	Size "E"	6	566.6	95.5	Cord failed at end of splice.
Type II 550 lbs.	Size "F"	3	571.6	96.4	Cord failed at end of splice.
Type II 550 lbs.	Size "F"	6	573.3	96.7	Cord failed at end of splice.
Type VI 2000 lbs.	Size "E"	3	1,345	55.9	Stitching failed.
Type VI 2000 lbs.	Size "F"	3	1,530	63.6	Stitching failed.
					MIL-C-7515, 550 lbs. t.s. Control = 593 lbs.
					MIL-C-7515, 2000 lbs. t.s. Control = 2405 lbs.

TABLE IV

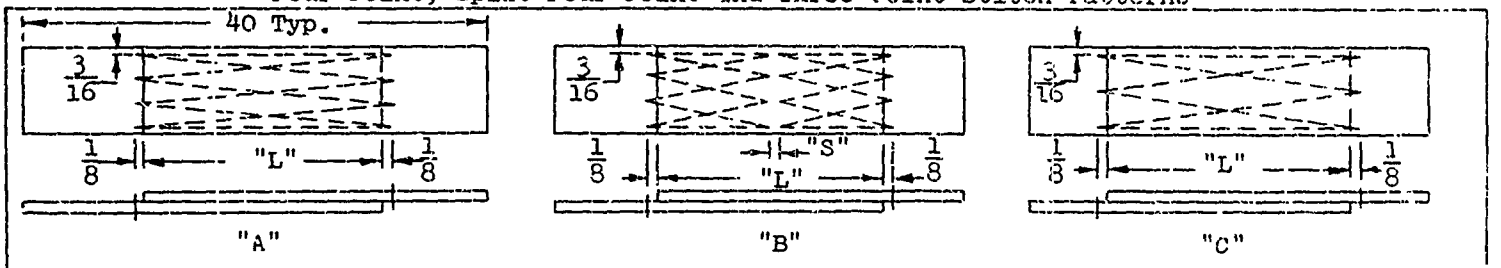
CORD JOINT TESTS - PHASE II - SERIES II



NYLON CORD MIL-C-7515	THREAD MIL-T-7807	"L"	AVERAGE BREAKING STRENGTH	"S"	EFF. %	COMMENT
Type VI, 2000 lbs.	"F"	6	2340	2	97.3	Cord failed at "A".
Type VI, 2000 lbs.	"FF"	6	2346	2	97.5	Cord failed at "B".
Type II, 550 lbs.	"F"	6	590	2	99.5	Cord failed at end of stitching.
Type II, 550 lbs.	"FF"	6	580	2	97.8	Cord failed at end of stitching.
						MIL-C-7515, 2000 lbs.t.s. Control - 2405 lbs.

TABLE V

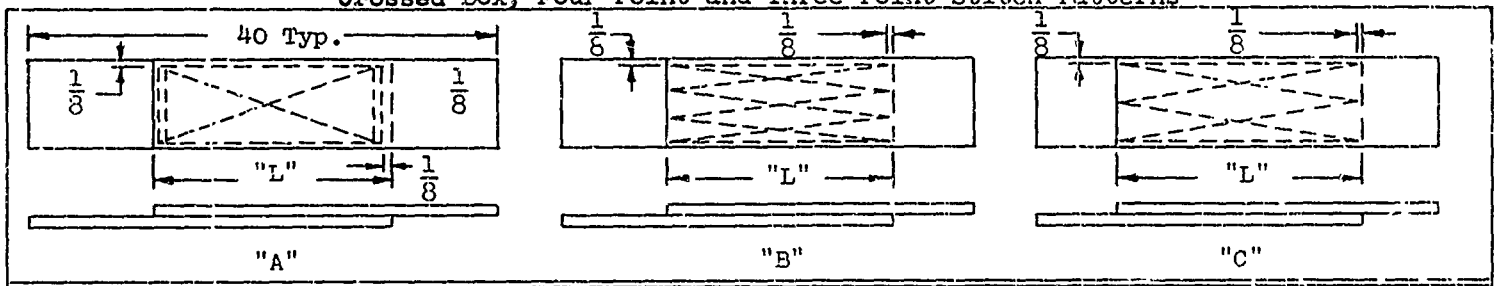
Four Point, Split Four Point and Three Point Stitch Patterns



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1000 lbs. t.s.	"FF"	8	"A"	6	-	III	1305	88.4	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1000 lbs. t.s.	"FF"	8	"A"	4	-	III	1317	89.2	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1000 lbs. t.s.	"FF"	8	"B"	6	2	III	1350	91.5	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1000 lbs. t.s.	"F"	8	"A"	6	-	III	1372	92.9	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 3000 lbs. t.s.	3 cord	8	"A"	4	-	IV	3512	86.9	Webbing failed at end of stitching on all specimens
MIL-W-5625, 3000 lbs. t.s.	3 cord	8	"B"	6	2	IV	3600	89.1	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 3000 lbs. t.s.	3 cord	8	"C"	4	-	III	3230	79.9	Stitching failed on one specimen, webbing failed on rest.
MIL-W-5625, 3000 lbs. t.s.	3 cord	5	"C"	6	-	IV	3037	75.2	Stitching failed.
									MIL-W-5625, 1/2", 1000 lbs. Control = 1476 lbs.
									MIL-W-5625, 1" w., 3000 lbs. Control = 4040 lbs.

TABLE VI

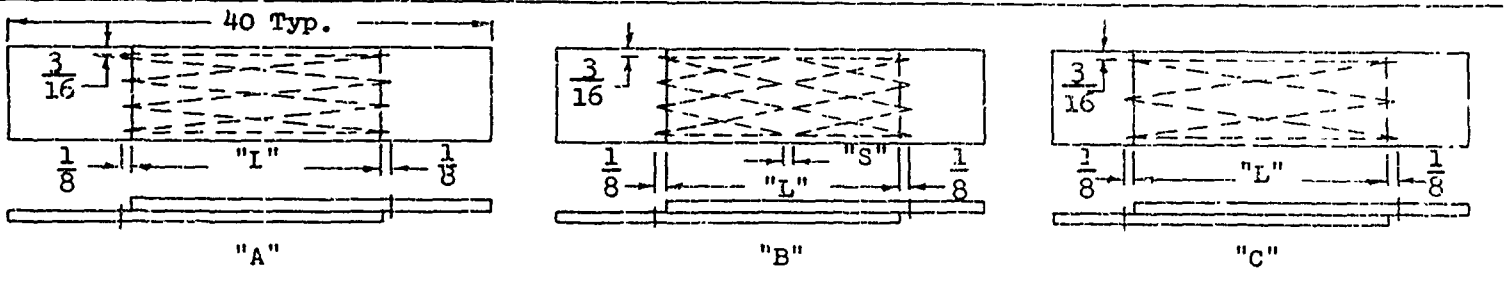
Crossed Box, Four Point and Three Point Stitch Patterns



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625 1/2" w., 1000 lbs.	"FF"	8	"C"	6	-	III	1162	78.7	Webbing failed at end of stitching.
MIL-W-5625 1/2" w., 1000 lbs.	"F"	8	"C"	6	-	III	1235	83.6	Webbing failed at end of stitching.
MIL-W-5625 1" w., 3000 lbs.	3 cord	8	"C"	6	-	IV	3063	75.8	Webbing failed at end of and along line of stitching.
MIL-W-5625 1" w., 3000 lbs.	3 cord	11	"B"	4	-	IV	3045	75.4	Webbing failed along line o stitching.
MIL-W-5625 1" w., 3000 lbs.	3 cord	11	"C"	4	-	IV	3173	78.5	Webbing failed along line of stitching.

TABLE VII

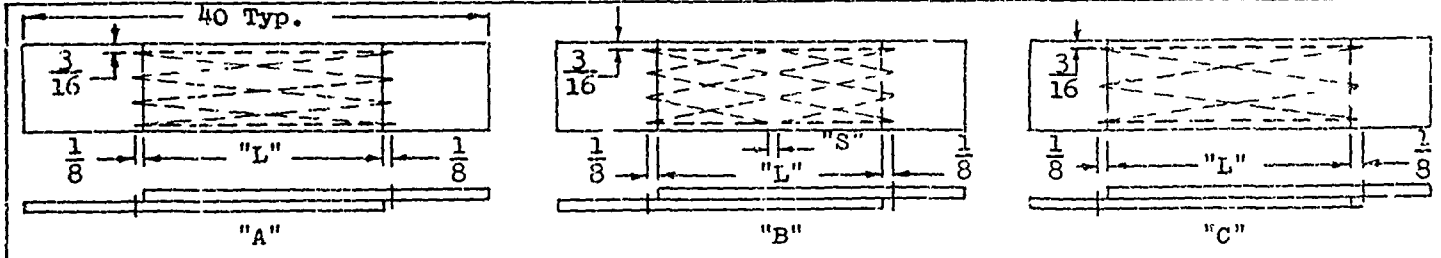
Four Point, Split Four Point and Three Point Stitch Patterns



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1/2"w,1000 lbs.	"F"	5	"C"	6		III	1378	93.4	Stitching failed on one specimen, webbing failed on rest.
MIL-W-5625, 1/2"w,1000 lbs.	"F"	11	"C"	6		III	1328	89.9	Webbing failed at end of stitching.
MIL-W-5625, 1/2"w,1000 lbs.	"FF"	5	"C"	6		III	1418	96.1	Webbing failed at end of stitching.
MIL-W-5625, 1/2"w,1000 lbs.	"FF"	11	"C"	6		III	1297	87.9	Webbing failed at end of stitching.
MIL-W-5625, 1" w.,3000 lbs.	3 cord	5	"A"	4		IV	3220	79.7	Webbing failed along stitching on one specimen, stitching failed on rest
MIL-W-5625, 1" w.,3000 lbs.	3 cord	11	"A"	4		IV	3313	82.0	Webbing failed at end of stitching.
MIL-W-5625, 1" w.,3000 lbs.	3 cord	5	"B"	6	2	IV	3730	92.3	Webbing failed at end of stitching.
MIL-W-5625, 1" w.,3000 lbs.	3 cord	11	"B"	6	2	IV	3480	86.1	Webbing failed at end of stitching.

TABLE VIII

Four Point, Split Four Point and Three Point Stitch Patterns.

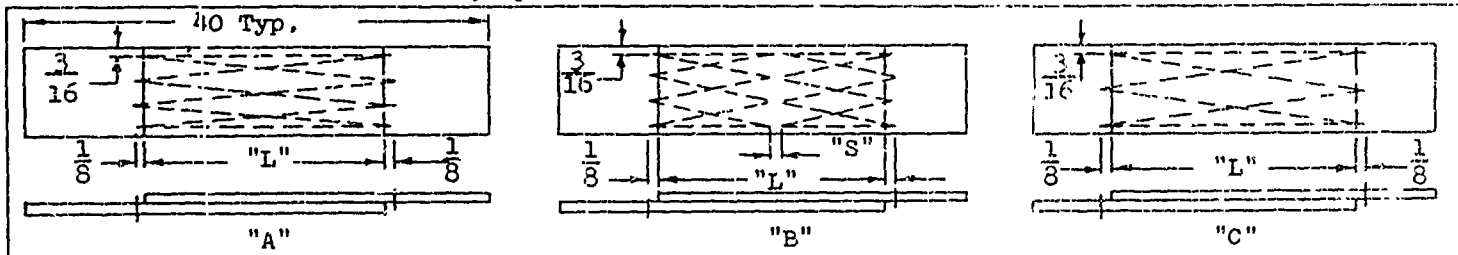


NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, ½"w.,1000 lbs.	"E"	8	"C"	6	-	III	1316	89	One stitch failure. Webbings failed at stitch ends on the rest.
MIL-W-5625, ½"w.,1000 lbs.	"F"	8	"C"	6	-	III	1432	97	Webbing failed at end of stitching.
MIL-W-5625, ½"w.,1000 lbs.	"FF"	8	"C"	6	-	III	1470	99.6	Webbing failed at end of stitching.
MIL-W-5625, 1"w.,3000 lbs.	"F"	8	"C"	6	-	IV	2090	52	Stitching failed on all specimens.
MIL-W-5625, 1"w.,3000 lbs.	"FF"	8	"C"	6	-	IV	2646	66	Stitching failed on all specimens.
MIL-W-5625, 1"w.,3000 lbs.	3 cord	8	"C"	6	-	IV	3746	93	Webbing failed at end of stitching.
MIL-W-5625, 1"w.,3000 lbs.	5 cord	6	"C"	6	-	IV	3307	81.9	Webbing failed at end of stitching.
MIL-W-5625, 1"w.,3000 lbs.	3 cord	11	"C"	6	-	IV	3833	94.9	Webbing failed at end of stitching.

MIL-W-5625, 1/2", 1000 lbs. Control = 1476 lbs.
MIL-W-5625, 1" w., 3000 lbs. Control = 4040 lbs.

TABLE IX

Four Point, Split Four Point and Three Point Stitch Patterns

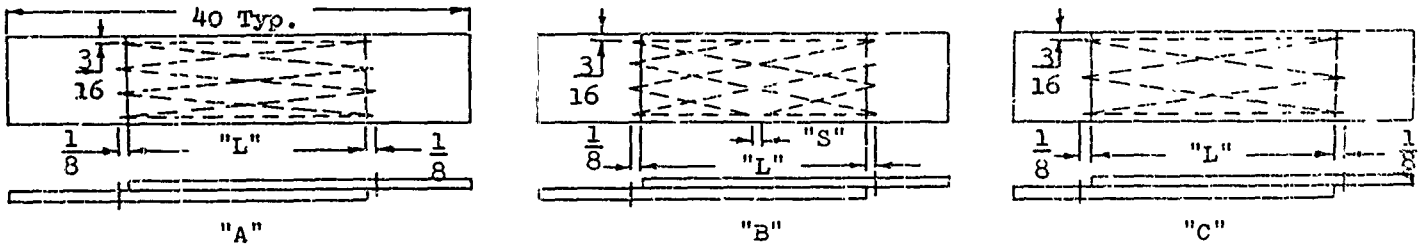


NYLON WEBBING*	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-4088, Ty.X,8700 lbs.	6 cord	6	"A"	8	-	V	8050	82.1	Stitching failed on one specimen. Webbing failed at stitch end on others.
MIL-W-4088, Ty.X,8700 lbs.	6 cord	6	"A"	7	-	V	7803	79.6	Stitching failed on one specimen. Webbing failed at stitch end on others.
MIL-W-4088, Ty.X,8700 lbs.	6 cord	6	"B"	$8\frac{1}{2}$	$\frac{1}{2}$	V	7953	81.1	Stitching failed on one specimen. Webbing failed at stitch end on others.
MIL-W-4088, Ty.X,8700 lbs.	6 cord	6	"B"	$7\frac{1}{2}$	$\frac{1}{2}$	V	7993	81.5	Webbing failed at stitch end on all specimens.
MIL-W-4088, Ty.X,8700 lbs.	5 cord	6	"A"	8	-	VI	7263	74.1	Stitching failed on all specimens.
MIL-W-4088, Ty.X,8700 lbs.	5 cord	6	"A"	7	-	VI	7277	73.2	Stitching failed on all specimens.
MIL-W-4088, Ty.X,8700 lbs.	5 cord	6	"B"	$8\frac{1}{2}$	$\frac{1}{2}$	VI	7600	77.5	Stitching failed on one specimen. Webbing failed at stitch end on others.
MIL-W-4088, Ty.X,8700 lbs.	5 cord	6	"B"	$7\frac{1}{2}$	$\frac{1}{2}$	VI	7107	72.5	Stitching failed on all specimens.

*Average Control Strength of Webbing = 9800 lbs.

TABLE X

Four Point, Split Four Point and Three Point Stitch Pattern

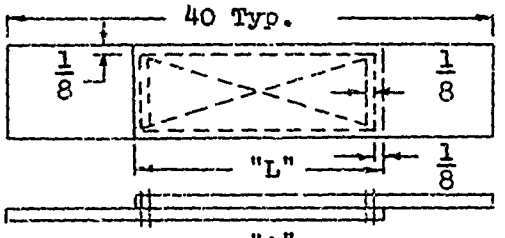


NYLON WEBBING*	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-4088, Ty. XIII	6 cord	6	"A"	6	-	V	6273	85.8	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty. XIII	6 cord	6	"A"	8	-	V	6053	82.8	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty. XIII	6 cord	6	"B"	6 1/2	1/2	V	5980	81.8	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty. XIII	6 cord	6	"B'	8 1/2	1/2	V	6327	86.5	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty. XIII	5 cord	6	"A"	6	-	VI	6347	86.8	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty. XIII	5 cord	6	"A"	8	-	VI	5943	81.3	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty. XIII	5 cord	6	"B"	6 1/2	1/2	VI	6047	82.7	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty. XIII	5 cord	6	"B"	8 1/2	1/2	VI	6000	82.1	Webbing failed at end of stitching on all specimens.

* MIL-W-4088, 6000 lbs. t.s. Control = 7313 lbs.

TABLE XI

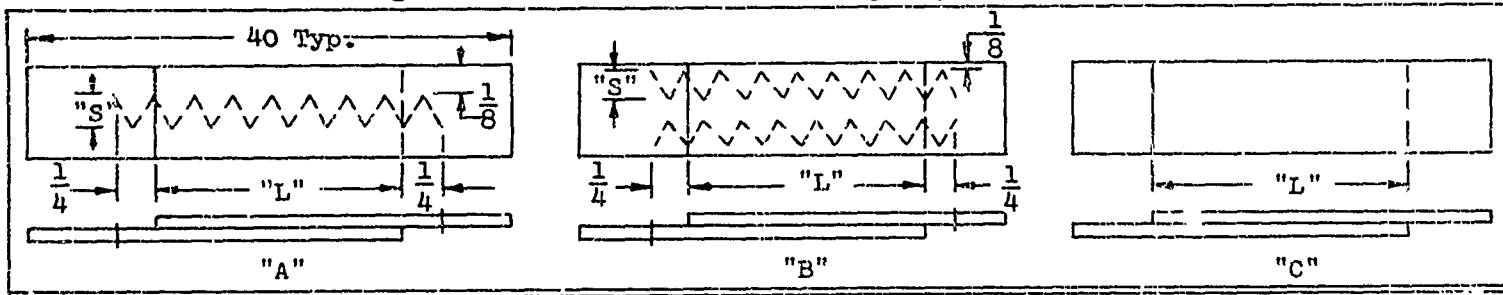
Cross Box Stitch Pattern



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1/2"W., 1000 lbs.	"F"	8	"A"	6	-	VII	1370	92.8	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2"W., 1000 lbs.	"FF"	8	"A"	6	-	VII	1403	95.1	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2"W., 1000 lbs.	"F"	8	"A"	4	-	VII	1323	89.6	Webbing failed on one specimen, stitching failed on the rest.
MIL-W-5625, 1/2"W., 1000 lbs.	"FF"	8	"A"	4	-	VII	1377	93.3	Webbing failed on one specimen, stitching failed on the rest.
MIL-W-5625, 1" W., 3000 lbs.	"F"	8	"A"	6	-	VIII	1560	38.6	Stitching failed on all specimens.
MIL-W-5625, 1" W., 3000 lbs.	"FF"	8	"A"	6	-	VIII	1725	42.7	Stitching failed on all specimens.

TABLE XII

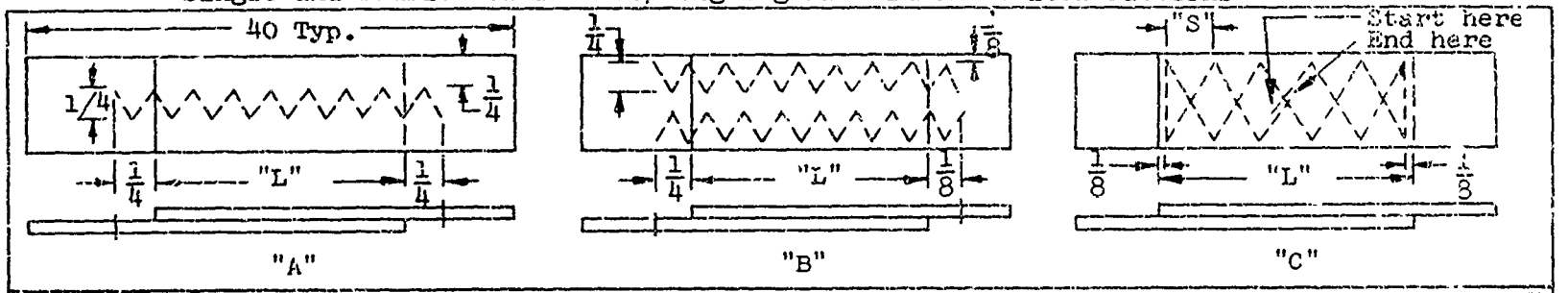
Single and Double Row Two-Step Zig-Zag Stitch Patterns



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1/2" w.,1000 lbs.	"E"	8	"A"	6	1/4	IX	1010	68	Stitch failed on all specimens.
MIL-W-5625, 1/2" w.,1000 lbs.	"F"	8	"A"	6	1/4	IX	1326	90	Webbing failed at stitch end. (1) Stitching failed. (2)
MIL-W-5625, 1/2" w.,1000 lbs.	"FF"	8	"A"	6	1/4	IX	1358	92	Webbing failed at stitch end on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	"E"	8	"B"	6	1/4	X	1933	48	Stitch failed on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	"F"	8	"B"	6	1/4	X	2526	63	Stitch failed on all specimens.
MIL-W-5625 1" w., 300 lbs.	"FF"	8	"B"	6	1/4	X	3423	85	Webbing failed at stitch end on all specimens.

TABLE XIII

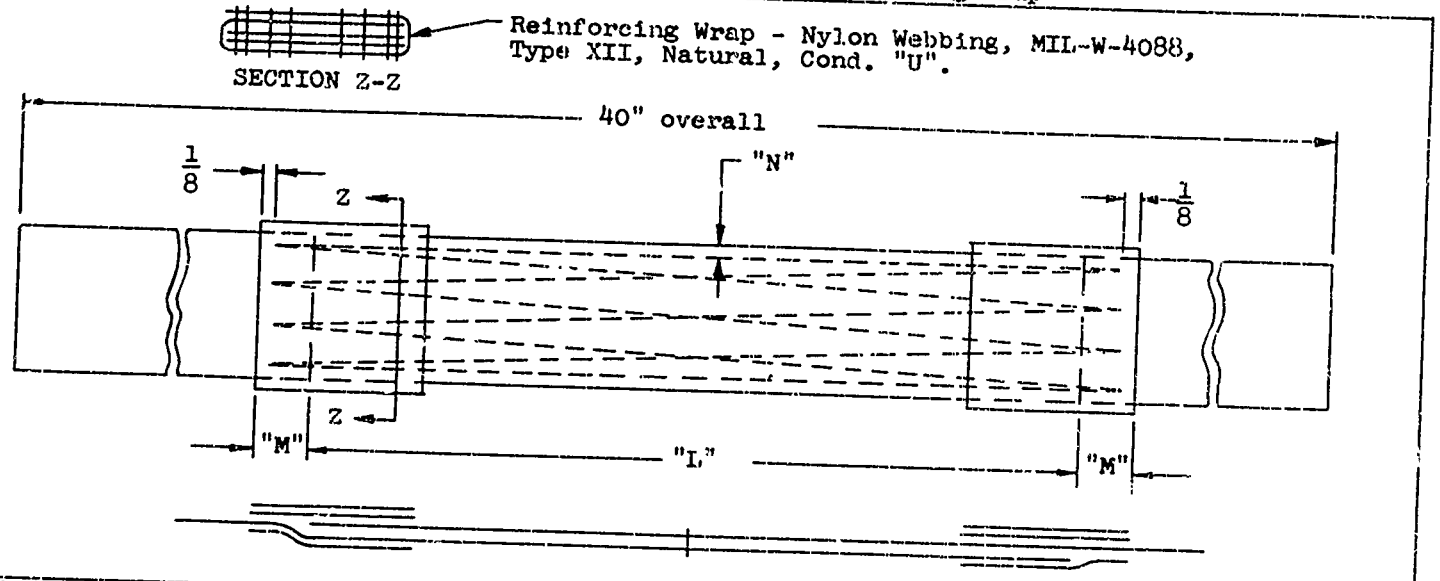
Single and Double Row Two-Step Zig-Zag and Diamond Stitch Patterns



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"C"	6	1	X	3123	77.3	Webbing failed at end of stitching on one specimen. Stitching failed on the rest.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"C"	4	1	X	2448	60.6	Stitching failed on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"C"	6	1/2	X	3277	81.1	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"C"	4	1/2	X	3227	72.9	Stitching failed on one specimen. Webbing failed at stitch end on the rest.
									MIL-W-5625, 1" w., 3000 lbs. Control = 4040 lbs.

TABLE XIV

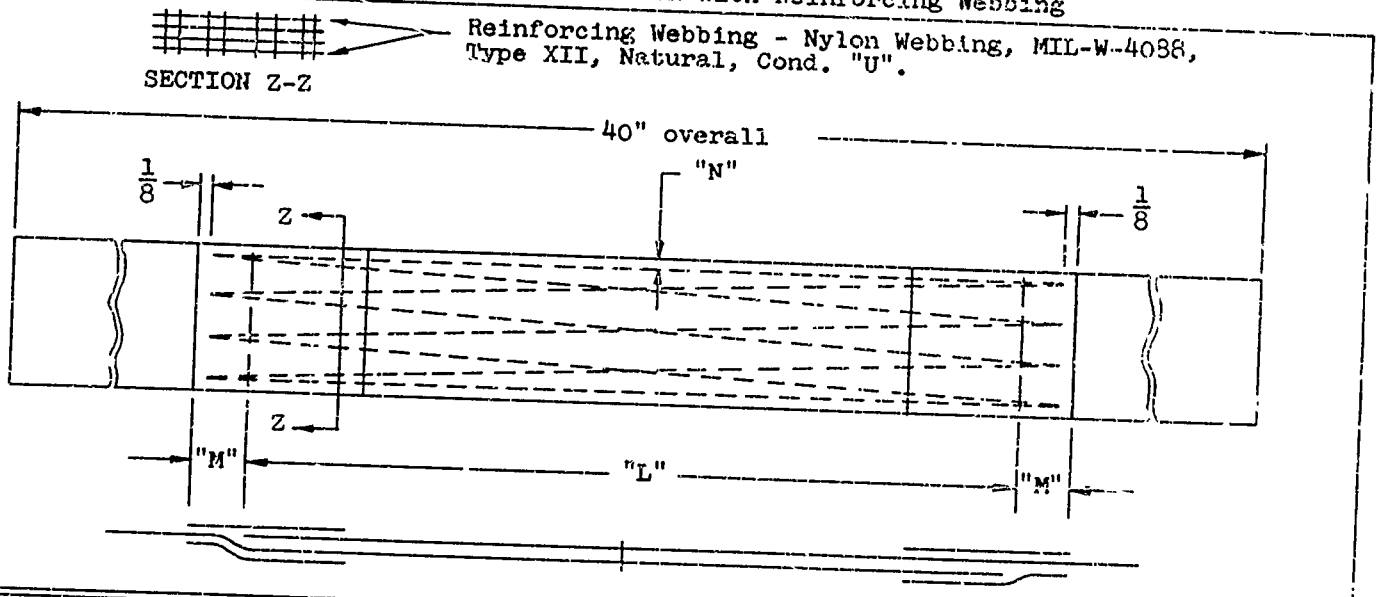
Four Point Stitch Pattern with Reinforcing Wrap



NYLON WEBBING*	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"M"	"N"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-4088, Type X, 8700 lbs.	6 cord	6	Reinf. End	6	5/8	3/16	XI	7993	81.5	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Type X, 8700 lbs.	6 cord	6	Reinf. End	8	5/8	3/16	XI	8016	81.7	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XIII,6000 lbs.	6 cord	6	Reinf. End	4	5/8	3/16	XI	6100	83.4	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XIII,6000 lbs.	6 cord	6	Reinf. End	6	5/8	3/16	XI	5947	81.3	Webbing failed at end of stitching on all specimens.
Ty.XIII,6000 lbs. *Control Strength = 7313 lbs.										*Average Control Strength of Type X Webbing = 9800 lbs.

TABLE XV

Four Point Stitch Pattern with Reinforcing Webbing



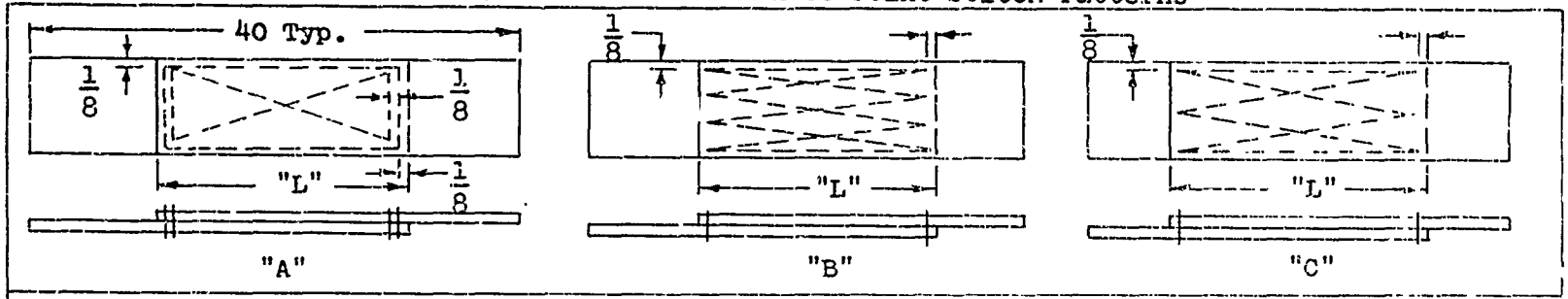
NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"M"	"N"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-4088, Type X, 8700 lbs.	6 cord	6	Reinf. Ends	6	5/8	3/16	XII	8173	83.3	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Type X, 8700 lbs.	6 cord	6	Reinf. Ends	8	5/8	3/16	XII	8160	83.2	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XIII, 6000 lbs.	6 cord	6	Reinf. Ends	4	5/8	3/16	XII	6353	86.9	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XIII, 6000 lbs.	6 cord	6	Reinf. Ends	6	5/8	3/16	XII	6197	84.7	Webbing failed at end of stitching on all specimens.

Average Control Strength of Type XIII Webbing = 7313 lbs.

Average Control Strength of Type X Webbing = 9800 lbs.

TABLE XVI

Cross Box, Four Point and Three Point Stitch Patterns

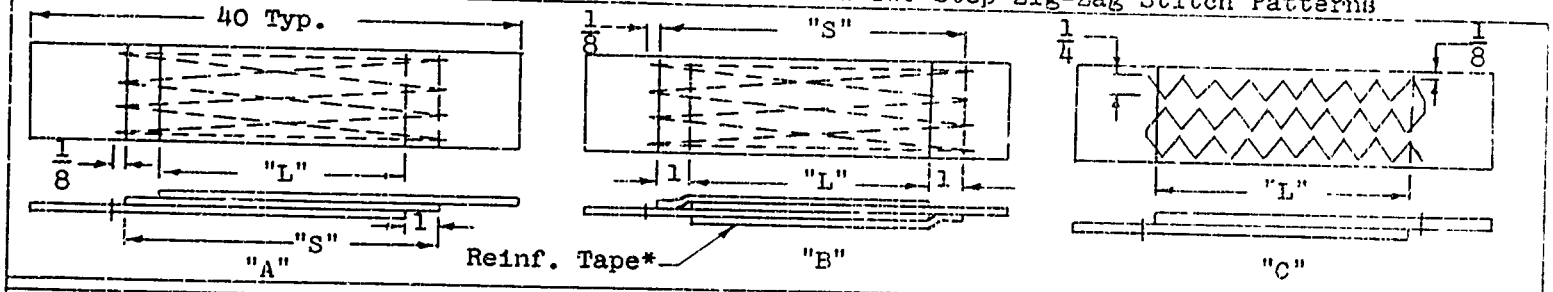


NYLON WEBBING	TH'D SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	6	"A"	6	-	XIII	2720	42.3	Stitching failed on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	6	"A"	8	-	XIII	3153	49.0	Stitching failed on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	6	"B"	6	-	XIV	3847	59.8	Stitching failed on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	6	"B"	8	-	XIV	4280	66.5	Stitching failed on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	6	"C"	6	-	XV	3520	54.7	Stitching failed on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs	3 cord	6	"C"	8	-	XV	4067	63.2	Stitching failed on all specimens.

Control Strength of 6000 lbs. t.s. Webbing = 6433 lbs.

TABLE XVII

Reinforced Four Point and Three Row Two-Step Zig-Zag Stitch Patterns

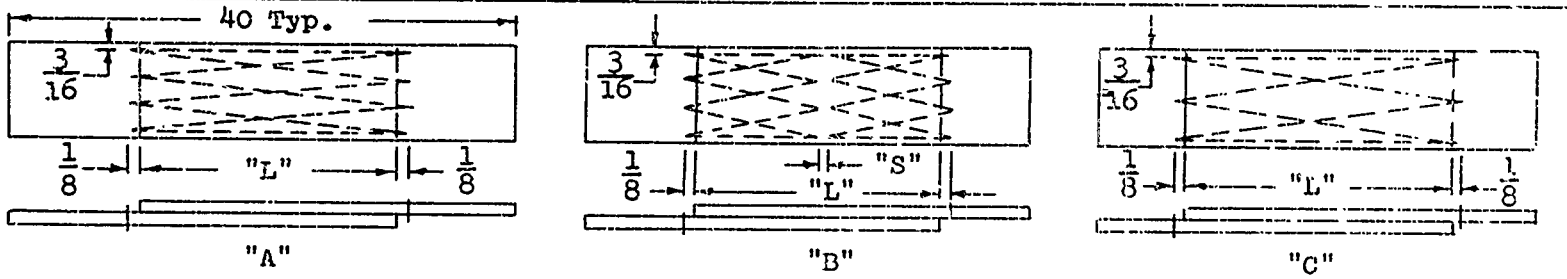


NYLON WEBBING	TH'D SIZE	ST./IN	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	8	"A"	8	10	XVI	6177	96.0	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	8	"A"	6	8	XVI	6147	95.6	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	8	"B"	8	10	XVII	6200	96.4	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	8	"B"	6	8	XVII	6440	100.1	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	8	"C"	8	-	XVIII	6307	98.1	Stitching failed on one specimen, webbing failed on the rest.
MIL-W-4088, Ty.XVIII,6000 lbs.	3 cord	8	"C"	6	-	XVIII	5493	85.4	Stitching failed on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	6 cord	6	"A"	6	8	XIX	6173	96.0	Webbing failed at end of stitching on all specimens.
MIL-W-4088, Ty.XVIII,6000 lbs.	6 cord	6	"A"	4	6	XIX	6000	93.3	Webbing failed at end of stitching on all specimens.

Average Control Strength of 6000 lbs. Webbing = 6433 lbs.
*Reinforcing Tape, MIL-T-5038, Type IV, 1000 lbs. t.s., 1" wide.

TABLE XVIII

Four Point, Split Four Point and Three Point Stitch Patterns

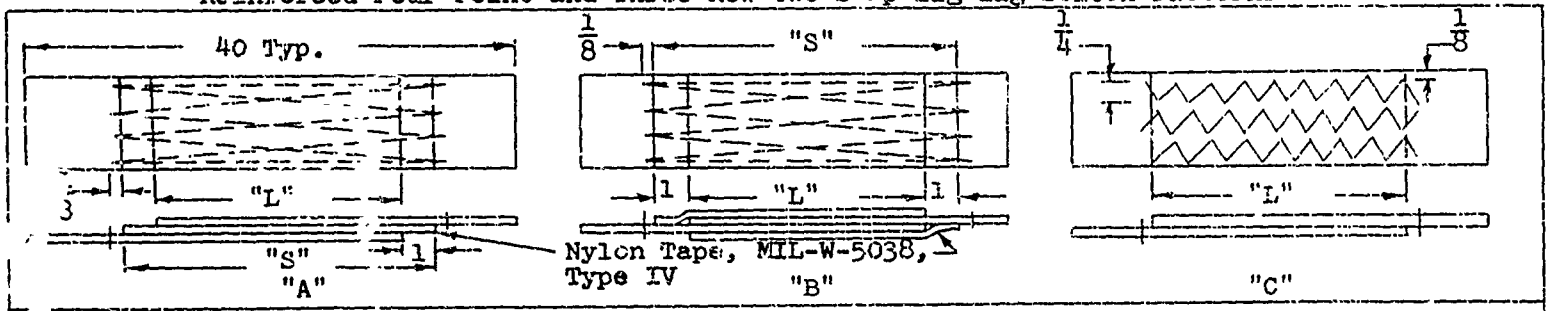


NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-4088, 1" w., 6000 lbs.	6 cord	6	"A"	6	-	XX	5790	90.0	Webbing failed at stitch end on all specimens.
MIL-W-4088, 1" w., 6000 lbs.	6 cord	6	"A"	4	-	XX	5403	84.0	All specimens showed combination stitch and webbing failures.
MIL-W-4088, 1" w., 6000 lbs.	5 cord	6	"A"	6	-	XXI	5833	90.7	Webbing failed at stitch end on all specimens.
MIL-W-4088, 1" w., 6000 lbs.	5 cord	6	"A"	4	-	XXI	5220	81.1	Stitching failed on a 1 specimens.

Control Strength of 6000 lbs. t.s. Webbing = 6433 lbs.

TABLE XIX

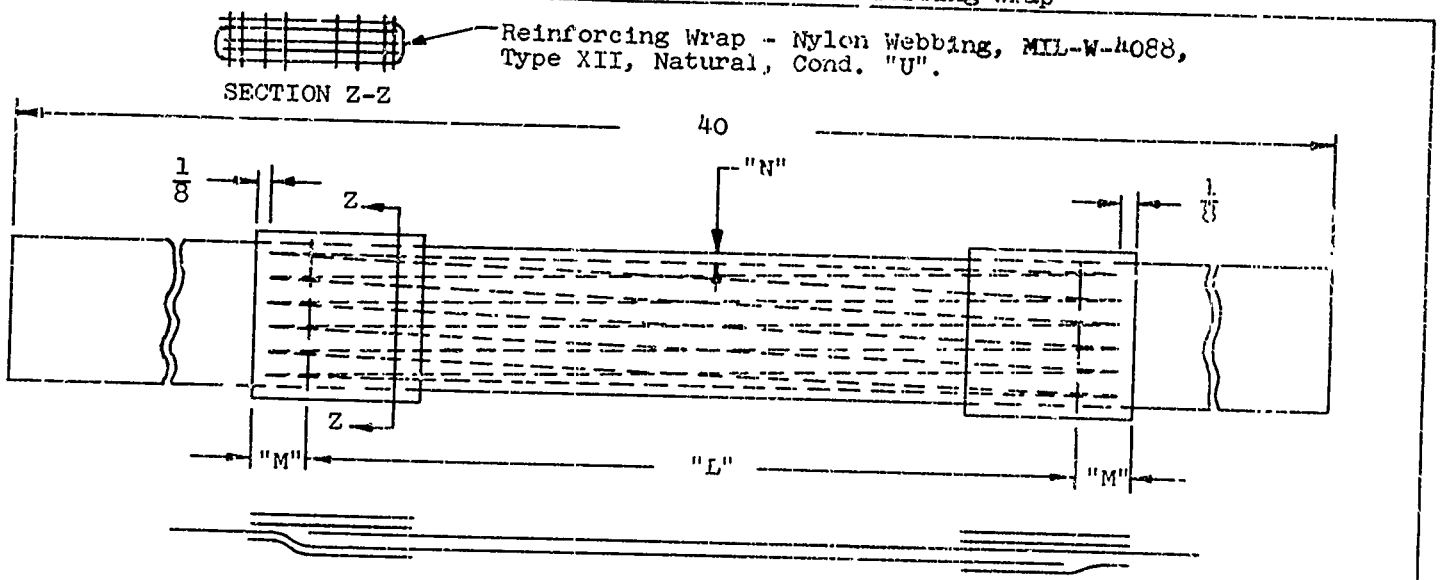
Reinforced Four Point and Three Row Two-Step Zig-Zag Stitch Patterns



NYLON WEBBING	THD. SIZE	ST. IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"C"	6	-	XXII	3560	88.1	Webbing failed at end and along line of stitching.
MIL-W-5625, 1" w., 3000 lbs.	6 cord	6	"A"	6	8	XXII	3500	86.6	Webbing failed at end and along line of stitching.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	4	"C"		-	XXII	2580	63.9	Stitching failed.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	11	"C"	4	4	XXII	3447	85.3	Webbing failed at end and along line of stitching.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"A"	8	10	XXII	3487	86.3	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"A"	6	8	XXII	3693	91.4	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"B"	8	10	XXII	3513	87	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1" w., 3000 lbs.	3 cord	8	"B"	6	8	XXII	3340	82.7	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 3000 lbs. Control - 4040 lbs.									

TABLE XX

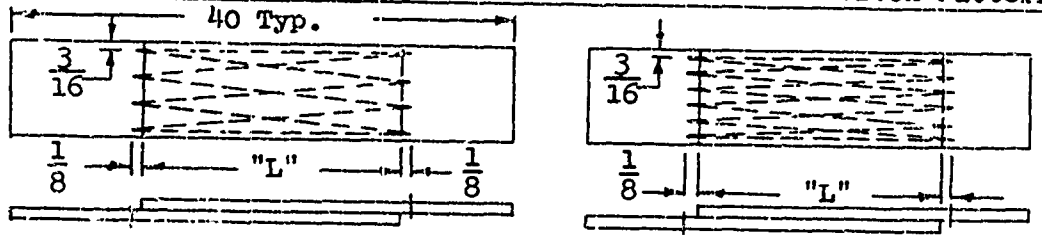
Six Point Stitch Pattern with Reinforcing Wrap



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"M"	"N"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5787, Ty. II, 40,000lbs.	8 cord	6	Reinf. End	10	5/8	3/16	XXIII	31,600		Stitching failed on all specimens.
MIL-W-5787, Ty. II, 40,000lbs.	8 cord	6	Reinf. End	14	5/8	3/16	XXIII	35,500		Webbing failed at end of overlap on one specimen, stitching failed on rest.
MIL-W-5787, Ty. I, 20,000lbs.	8 cord	6	Reinf. End	10	5/8	3/16	XXIV	21,000		Webbing failed at overlap on all specimens.

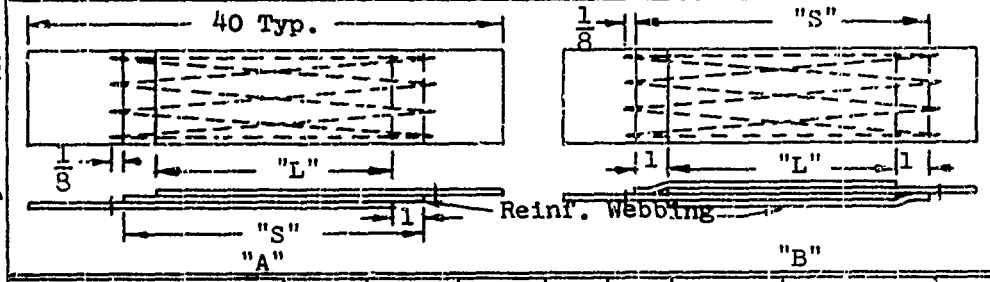
TABLE XXI

Five Point and Six Point Stitch Patterns



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	EFF. %	SERIES NO.	BREAKING STRENGTH (AVERAGE)	COMMENT
MIL-W-5787, Ty.I,20,000 lbs	8 cord	6	"A"	8		XXIV	12,630	Stitching failed on all specimens.
MIL-W-5787, Ty.I,20,000 lbs	8 cord	6	"B"	8		XXIV	18,600	Stitching failed on one specimen. Webbing failed at overlap on rest.

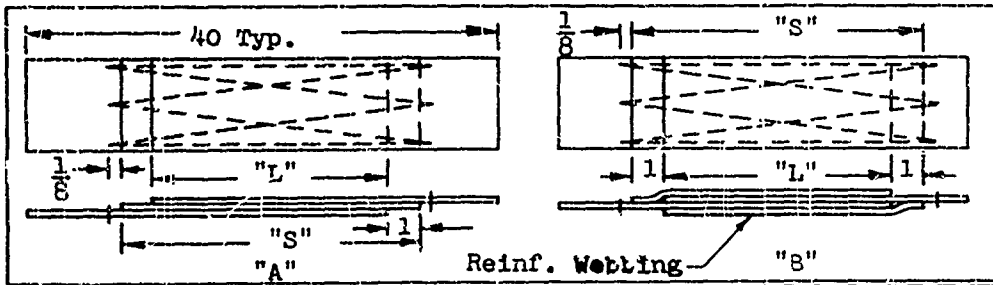
TABLE XXII
Reinforced Four Point Stitch Patterns



NYLON WEBBING	TH'D.	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	"B"	4	6	XXV	1338	90.9	Webbing failed at end of stitching.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	"B"	6	8	XXV	1318	89.5	Webbing failed at end of stitching.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	"A"	6	8	XXV	1340	91.0	Webbing failed at end of stitching.
MIL-W-4088, Type X, 8700 lbs.	6 cord	6	"A"	8	10	XXVI	8620	88.0	Webbing failed at end of stitching on one specimen, stitching failed on rest.
MIL-W-4088, Type X, 8700 lbs.	6 cord	6	"B"	8	10	XXVI	9100	92.9	Webbing failed at end of stitching on all specimens.

TABLE XXIII

Reinforced Three Point Stitch Patterns



NYLON WEBBING	TH'D. SIZE	ST./IN.	OVER-LAP TYPE	"L"	"S"	SERIES NO.	BREAKING STRENGTH (AVERAGE)	EFF. %	COMMENT
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	"A"	4	6	XXVII	1375	93.2	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	"A"	6	8	XXVII	1490	100.9	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	"B"	4	6	XXVII	1405	95.2	Webbing failed at end of stitching on all specimens.
MIL-W-5625, 1/2" w., 1000 lbs.	"FF"	8	"B"	6	8	XXVII	1488	100.8	Webbing failed at end of stitching on all specimens.
									MIL-W-5625, 1000 lbs. t.s. Control = 1476 lbs.
									*Nylon Webbing, MIL-W-4088, Type I, 9/16" wide, 500 lbs. t.s.